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*Document Version*

Publisher's PDF, also known as Version of record

*Publication date:*

1997

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Rossum, W. V. (1997). *The implementation of technologies in intensive care units: ambiguity, uncertainty and organizational reactions*. s.n.

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# **THE IMPLEMENTATION OF TECHNOLOGIES IN INTENSIVE CARE UNITS: AMBIGUITY, UNCERTAINTY AND ORGANIZATIONAL REACTIONS**

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SOM theme B: Inter-firm coordination and change

## **Abstract**

In organizational studies different conceptualizations of the implementation of technologies in organization still prevail. Initially, deterministic theories were formulated in which organizational structures were adaptations to the exigencies of hardware technologies. Later, and in line with the earlier view, contingency theorists conceived of organizational structure as organizational technology, to accommodate characteristics of the environment (among which (rapidly changing) (hardware) technologies). In reaction to these conceptualizations, in the 1990s, new views were proposed, based upon general sociological insights. Now implementing technologies was considered to be part of the social processes within organizations. However, by focusing upon more general sociological insights (respectively, role theory and structuration theory) the research questions shifted from the context of organizational studies towards sociology in general. In fact, one can consider the most recent studies equally as part of the sociology of technology and organizational science.

In the present paper, an attempt is made to reconcile the more general sociological views with organizational science proper, by addressing the effects of technology implementation on the ambiguity of organizational goals.

In this way, it is argued, the newer and earlier conceptualizations can be subsumed under one, more general theory.

The theory presumes that the implementation of technology not only affects the uncertainty faced by the organization (the position of contingency theory), but also the ambiguity of its objectives. Consequently, organizations will develop organizational mechanisms to solve this ambiguity. It is assumed that the effects of technology implementation on uncertainty have to be specified for the various solutions of ambiguity.

The theory is applied to the case of technology implementation in Intensive Care Units (ICUs). ICUs are characterized by the implementation of a range of medical technologies. Especially in this case, involving decisions with respect to life and death, one can see the effects of the implementation of these technologies on the ambiguity of the objectives of ICUs.

Several hypotheses are formulated regarding each different type of ICUs as to the chosen solution for the ambiguity problem; the differential use of technologies within these ICU types and, finally, the effect thereof on the different contingencies encountered by each type of ICU.

In the empirical part of the paper the theory is tested by analyzing the implementation of technology in 80 European ICUs. The data were collected as part of the EU BIOMED project EURICUS-1. The objective of this comparative study in 13 European countries was to analyze the effects of non-medical factors on medical performance.

It is found that the different interpretations of the objectives of ICUs (as measured by different combinations of Length of Stay and Severity of Illness); resulting in four types of ICUs are strongly related to environmental factors. Moreover, an effect could be established between the country to which the ICU belonged and different interpretations of the objectives of the ICUs. Furthermore, technology use and uncertainty within the ICUs appeared to be related to the nature of the interpretations of objectives.

## **1. Introduction**

In organization science, the relationship between the implementation of technologies and organizational structure is still a matter of debate.

Initially, and in reaction to classical organization science (emphasizing generally applicable rules of organizing), organization scientists studying the implementation of technologies in organizati-

ons noted the different organizational structures needed by the implementation of different technological processes (Thompson and Bates, 1957; Woodward, 1958). In this view technologies are the external stimuli for the development of organizational structures.

This view was later to be elaborated, and eventually to be modified, in the contingency perspective. Technological change is now considered one of the external sources of uncertainty with which organizations have to deal (see, for example, Perrow, 1967, 1970; Mintzberg, 1979, and Scott and Comstock, 1977/1987).

The contingency perspective is far more elaborated than the initial Thompson/Bates and Woodward approaches in detailing the attributes of the organizational answers to technological uncertainty.

For example, Perrow indicates different types of organizational structure related to the extent to which the uncertainty is 'understood' by the organization, and results in analyzable search. Scott and Comstock elaborate this view further, by developing a theory of organizational reactions at the individual and collective level, to deal with what they call technological predictability (their term for what Perrow calls analyzable search).

The contingency perspective is a modification of the initial approach, in the sense that it does not explicitly deal with the implementation of technologies, only with its organizational consequences. Hence, when contingency theorists speak of technologies, they actually mean organizational technology (structure).

The contingency perspective on the relationship between technology and organizational structure has been empirically assessed (Hickson, et al., 1969; Mohr, 1971; Lynch, 1974; Overton, 1974 et al., 1977). Although these assessments were critical, and sometimes even challenged the base of the contingency view (see Mohr, 1971), the perspective still remained the mainstream interpretation of the relationship until the 1990s.

At that time, however, the perspective was more fundamentally criticized using various sociological theoretical approaches (Barley, 1990; Orlikowski, 1992).

Barley criticizes the contingency theorists's view on the relationship between technology and organizational structure as too static and involving a materialistic ontology. (Barley, 1990: 61-62).

In his view, contingency theorists wrongly assume that there are generally valid claims to be formulated regarding the relationships between types of technologies and types of organizational structures. The processual nature of the implementation of technologies in organizational is neglected (Barley, 1990:62). Furthermore, contingency theorists ignore the active role of humans in the development and implementation of technologies. Their assumption that non-social attributes of technologies cause organizational adaptation is unjustified (Barley, *ibid*).

Referring to other theories of the social aspects of the implementation of technologies, Barley then develops a (role) theory of the triggering effects of the introduction of technologies on the emerging non-social and social roles of the organization members using the technology. Empirically, he tests the theory in a longitudinal study of the structuring effects of the introduction of the CT scanner in two hospitals.

Orlikowski takes her starting point in a broad overview of different perspectives on the relationship between technology and organizational structure. She sees a fundamental difference between the 'technological imperative' model (the view as outlined above that conceives of the relationship in terms of external effects of technology upon social structure), and the 'strategic choice' model, taking the opposite view, i.e. emphasizing the social structuring, or even constructing, of technology. (Orlikowski, 1992: 400-402). Whereas the former is criticized as too deterministic, the second is, in her view, too voluntaristic.

Consequently, she chooses a third perspective, comparable to the approach followed by Barley, i.e., by conceiving of the technology as a 'trigger of structural change'. (Orlikowski, 1992:402). However, where Barley analyzes the triggering effects from a micro perspective as the development of roles in the organization, Orlikowski formulates a more encompassing perspective, applying Giddens's structuration theory: actors develop structures (among which technologies), and are subsequently constrained by these structures. Like Giddens, she tries to incorporate both a macro and micro approach, as well as a subjective and objective view of the relationship between technology and organizational structure. She uses the key concepts: '*dual nature*' of *technology*, wherein technology is seen as being simultaneously in the process of being produced and the structural context of that process; and '*interpretive flexibility*', i.e., the conception that technology can differently be interpreted (Orlikowski, 1992: 406-408). These concepts facilitate an empirical account of the development and subsequent implementation of a specific form of Computer-Aided Software Engineering as a social process of institutionalization.

By using general sociological theories in both new accounts of the relationship between technology and organizational structure, the specific organizational questions related with the implementation of technologies have shifted to the background. The focus is on the social rather than the organizational aspects of technology implementation.

However, neither author pays attention to another feature of the conceptualization of the relationship between technology and organizational structure in the contingency perspective: its restriction to a notion of technology implementation as only an uncertainty inducing factor.

The contingency perspective deals with the relationship between technology and organizational structure as predominantly a question of efficiency: it is rational for the organization to adapt its structure in order to reduce uncertainty stemming from the environment. They see fast changing

(hardware) technologies as one of the significant aspects of this environment. Hence, in order to efficiently reach their objectives, organizations have to adapt their structures to the exigencies of technological change.<sup>1</sup>

In this view the objectives of the organization are considered to be a fixed reference point. Like economists, organization scientists for the most part consider social reality in terms of choices of alternatives, given an unchangeable utility function (March, 1988; 1994). Given these assumption, changes in objectives or preferences are not being addressed.

However, one can question to what extent the implementation of technologies does *not* alter the objectives of organizations.

There are empirical examples of technologies that were initially implemented with specific functions in mind, but were subsequently used in such a way that new objectives of the organization emerged. The implementation of the personal computer in organizations can provide many examples of this process.

In fact, indications of such effects of technology implementation on the objectives of organizations can be found in Barley's and Orlikowski's contributions.

If technology implementation triggers role changes, this can result in the definition of new objectives within the organization. In a similar vein, the 'interpretive flexibility' of technologies can involve the utilization of the technology to develop new goals.

This paper posits that a 'third way' is possible in the conceptualization of the relationship between technology implementation and organizational structure, combining the insights of contingency theorists and critics such as Barley and Orlikowski. This conceptualization focuses on the effects technology implementation will have on organizational objectives. March's notion of decisionmaking in organizations under uncertainty and ambiguity will be taken as the starting point for this theory.

The theory will be applied in a special case: technology implementation in Intensive Care Units (ICUs). ICUs are the subunits in hospitals in which critically ill patients are monitored and treated. In this case, I will argue that there is a special relationship between the multitude of medical technologies employed within the ICU and the objectives of the ICU (ICUs cannot be imagined without the prevalence of the various forms of technology facilitating the treatment of patients who would otherwise die).

Hypotheses derived from the theory will be tested on data from 80 European ICUs. The empirical data were collected as a part of the EU BIOMED study EURICUS-1, in which the effects of non-medical factors on medical performance of European ICUs were the central research object.

In the following paragraph the theory will be outlined, together with the relevancy of the theory

for the special case of technology implementation in ICUs. Four general hypotheses are formulated. Subsequently, the sample and operationalizations are described, and the data are analyzed. This is followed by a discussion of the analysis. Finally, the conclusions of the study are formulated.

## **2. Theory**

Ambiguity, according to March, is a common phenomenon in organizations:

Organizations frequently have ambiguous preferences and identities, ambiguous experiences and histories, ambiguous technologies, and fluid participation in decision-making.(March, 1994: 193).

Organizational objectives are often imprecise, vague and open for different interpretations. While the sources of ambiguity are different (see reference to March), they have the same consequence: one cannot take for granted the existence of clearcut, stable goals in organizations.

If this is an adequate account of organizations and their objectives, then it is surprising to note that many organization scientists assume the existence of fixed, mono-interpretable objectives of organizations. More in particular, when discussing the role of (hardware) technologies in organizations, the schools of organization scientists indicated above (except the critics Barley and Orlikowski), confine their analysis to the means of the organization, given the existence of fixed clearcut goals.

Technology implementation, considering the fast change of technologies, is considered a matter of uncertainty that can be reduced by organizational adaptations.

### **Technology and Ambiguity.**

March distinguishes uncertainty (dealing with unknown future alternatives) and ambiguity (dealing with unknown future preferences) (March, 1988: Chapter 13). Only in the former choices of alternatives are addressed: given the existence of a fixed utility function of preferences. In fact, technological change has been treated by contingency theorists as a factor resulting in the growth of the number of alternatives needing organizational adaptations.<sup>2</sup>

The latter concept deals with choices of preferences rather than alternatives. The discussion involves the nature and change of the objectives of the organization. In other words, how do we

deal with a future in which different preferences are feasible?

Let us presume that an organization will have such imprecise, multi-interpretable, ambiguous objectives. How do we conceptualize the contribution of technologies?

An attempt to answer this question leads to two other questions:

- To what extent can technologies contribute to the ambiguity of objectives?
- If technologies can contribute to the ambiguity of objectives, how do organizations deal with these effects?

Here, the contributions of Barley and Orlikowski prove to be helpful: if technologies have social aspects, as indicated by these authors (i.e., can change roles of organization members (Barley), or are interpretively flexible (Orlikowski)), the implementation of technologies can -- via such social mechanisms, influence then objectives of organizations and hence the ambiguity of objectives.

For example, Barley shows that the implementation of the CT scanner in two hospitals not only changes the non-relational (task-related) parts of the roles of the radiologists and technicians, but also the relational aspects of these roles. It seems that social change, triggered by the introduction of the CT-scanner, only influences the way radiologists and technicians do their work and their mutual relationships. This is, however, only part of the story (and medical technology is an especially good case for this scenario because of the rather loose relationship between technologies and the existing tasks of actors in a hospital environment).

The introduction of the CT-scanner in a hospital (as with most medical technologies) did not replace an existing technology (i.e., radiography and fluoroscopy), but was an addition to existing technologies (these did not vanish from the hospital stage). Hence, the new technology resulted in new jobs (i.e., the role of specific CT-scanner technicians and radiologists with specific CT-scanner experience), and new activities to be performed in the hospital. Similarly, the subsequent introduction of the MRI did not replace the CT-scanner. It was introduced as an addition to the existing array of diagnostic possibilities.

The introduction of such technologies not only influences the tasks and relationships of organizational members, but also -- and especially via these roles, the objectives of the hospital.

As Barley notes, currently "radiology departments encompass the 'angiography suite,' the 'CI department,' and the 'ultra-sound department,' as well as the 'main department' where radiography and fluoroscopy continue to be used much as they were in the past" (Barley, 1990:72).

The fact that these activities are now organized in different departments indicates the differences in work and role relationships go beyond the use of different methods to reach similar goals. The fact that the departments are still under the umbrella of the one hospital does not imply that the



objectives of these departments do not change. In recent years, for example, one notices the emergences of many 'imaging centres'. In these organizations the use of medical imaging techniques is an objective in itself; the ultimate consequence of the fact that the role of the radiologist has changed, triggered by the emergence of these new technologies.

Orlikowski's case also supports the view that technology implementation can have effects on objectives. She describes the development and use of a form of computer aided software engineering: a piece of information technology to be used by consultants who have to design computer systems attuned to the needs of different customers.

Orlikowski uses this case to show that the development and use of this technology can adequately be described as a form of structuration process; eventually resulting in the self-evident use of the instrument by organization members when consulting with customers.

She sees less interpretive flexibility of the technology in this case: the consultants could choose to alter -- or not to use the technology, but the constraints of their work situation are such that they will be inclined to use the instruments as is (although Orlikowski describes a case where consultants circumvented the use of the tool (Orlikowski, 1992, 419).

As she describes elsewhere in her paper, the users of a technology can have an effect on the objective of the organization by choosing not to use the technology (ibid, 410). However, there are also other ways to influence objectives.

Presume, for example, the use of CASE type tools in a situation where the consultants are no longer working for BETA (the consulting firm), but are directly employed by the firm producing the operating systems. A new type of organization can be envisaged using the technology as developed by BETA, but making organizations such as BETA -- as well as distributing firms, obsolete by directly linking customers to the production process.

The two examples show that technology implementation can result in effects on objectives, yet not on ambiguity. Technology implementation influences the level of ambiguity of organizational objectives in at least two ways:

- i) The implementation of technology results in new objectives which are not necessarily in line with existing objectives. If the existing objectives are still valid, this results in ambiguity within the organization. The two cases above provide examples of ambiguity when developing new objectives. If Barley's radiologists would have stayed within the same subunit, they would probably have experienced ambiguity in the objectives to be reached via the existing *and* the new technologies. Creating new subunits is, of course, an adequate organizational reaction to minimize the negative effects of such ambiguity.
- ii) The implementation of technology affects existing ambiguity in organizational objectives. This happens when the technology enables the organization to develop or to

reinforce ambiguous objectives. Military technology is a good example (the more offensive power created as a result of new technologies, the more the adversary will develop new technologies to counter these offensive technologies). Although such technologies are developed in order to reach the objective of military supremacy, the actual development of technologies reinforces the ambiguity of such goals. Similarly, many medical technologies are examples of technologies that facilitate the development and reinforcement of ambiguous objectives. The development of some of these, e.g., reproductive technologies, even result in the development of objectives in which the ambiguity is about the question of whether such technologies still enable health objectives.

The technologies being used in ICUs are prime examples of such ambiguity inducing technologies: ICUs are not conceivable without the technologies that facilitate keeping critically ill patients alive. However, the further development of such technologies reinforces the discussion about the different preferences regarding the role of medical technological knowledge with respect to life and death.

Such effects on ambiguity are consequences of a particular form of interpretive flexibility of technologies; where the different interpretations of the role of the technology interfere with different interpretations of the objective of organizations.

In the remainder of this paper, I will confine myself to the latter type of effect of technologies. I elaborate this special effect of technology implementation on ambiguity in the case of Intensive Care Units (ICUs).

## ICUs

Intensive Care Units are characterized by a high level of potential ambiguity with regard to their objectives. The central goal of the ICU is inherently ambiguous: to monitor and treat critically ill patients in order to 'buy time' for facilitating other curative interventions. When is a patient 'ill enough' to warrant treatment in an ICU?; when is a patient 'too ill' to be treated in an ICU? While the question of which patients should be admitted to the ICU will be 'generally' clear for ICU medical staff, the boundaries of the category 'potential ICU-patient' are not clear. Moreover, the extent to which these boundaries can be extended is strongly dependent on the availability and the use made of advanced medical technologies in ICUs. On the one hand, the more technologies are available in other subunits (e.g., medium care units, recovery rooms, wards), the more the boundary shifts towards the more critically ill patients. On the other side, the availability of more

advanced technologies within the ICU will extend the potential of the ICU to treat more critically ill patients.

There is yet another relationship between potential ambiguity and technology implementation in ICUs. ICUs treat patients with different types of illnesses, and focus on the multidisciplinary interventions directed towards the support or replacement of various organ and systems functions (i.e., respiratory, cardiovascular, and renal). Within the ICU, technologies are available that can monitor and support these three organ and system functions: respectively:

- *Respiratory function*: most ICUs will have mechanical ventilators, end-tidal CO<sub>2</sub> monitoring, pulse oximeter monitoring and portable ventilators.
- *Cardiovascular function*: the technologies comprise ECG monitoring, intravascular pressure modules, pacemakers, defibrillators, portable ECG and pressure monitors, and (in less ICUs) Intra-Aortic Balloon Pumps.
- *Renal function*: hemodialysis, peritoneal dialysis, hemofiltration techniques and infusion pumps.

Potentially, at least, the availability of such a battery of technologies can result in difficulties in defining the boundaries of the ICU itself (are patients treated within or external to the ICU?). Of course, availability of technology and aspects of role relationships between IC medical staff and other specialists are difficult to disentangle. Not only the decision to admit patients to the ICU is ambiguous; the decision to discharge patients from the ICU has similar attributes. For example, when - according to the medical staff within the ICU, a patient is too ill to warrant further treatment, should they still continue treatment to prolong the life of the patient or should they decide to discontinue treatment and discharge the patient to a ward or to go home to die?

In the case of so-called 'Do Not Resuscitate Orders', Zimmerman et al. (1986) refer to "substantial variations ... in physician attitudes in limiting therapy and the relative priority to assign to factors such as patient age and the anticipated quality of survival" (Zimmerman,et.al., 1986: 351). Such variations, according to these authors, are "more related to differences in physician treatment decisions than patient presentation" (op. cit.:355). If such differences exist, central decisions within the ICU concerning the admission and discharge of patients will be highly ambiguous.

In the case of the ICU these ambiguities of the central decisions of admission and discharge of patients are directly related to the implementation of technology. Professionals can opt not to use a technology in order to discontinue treatment or (less extreme), to move a patient to another ICU. Moreover, the development of even more advanced medical technologies, and the diffusion of technologies from other specialties to the ICU, result in a constant pressure on ICU medical

staff to extend the range of their activities: "the use of the technology can become an end in itself" (Byrne, 1997:1).

One thing is clear: adding more technologies to those already available in the ICU increases the potential ambiguity of objectives within the ICU.

The question is: how do ICUs deal with such technology-induced ambiguity?

## Organizational Reactions

Organizations address potential ambiguity within their ranks by the *loose coupling* of subunits (March, 1994:193).

Loose coupling refers to the fact that members and subgroups within the organization obtain a substantial degree of freedom to solve problems in their own way.

An example can be drawn from a different context. Notwithstanding the canons of the philosophy of science, research projects within different departments of one university will be characterized by different methodologies. Such differences are related to the different attributes of the various subject matter within the different departments (or, at least in some disciplines, different perspectives on the subject matter). In this way, potential ambiguity in the definition of what should be considered adequate scientific research is buffered by confining discussions within separate departments (and relevant disciplines). This precludes discussion at the level of the university. According to March, such 'buffering' is not simply an indicator of disorder within the organization, but is one of the mechanisms by which organizations solve the ambiguity problem (op. cit.:194).

Two mechanisms of loose coupling, as described by March, can be used as elements of the theory explaining how ICUs deal with the ambiguity inherent to their objectives. These mechanisms are i) the decentralization of decision making and the delegation of authority (or the loose coupling of subunits within the organization); and, ii) the loose coupling of the formulation of policy and the actual implementation of decisions (or the loose coupling of decision making). Rather than perceiving the objectives (or preferences) of ICUs as immutable, this approach allows different definitions of ICU objectives.

According to March, decentralization is not only an adequate way of bringing decision making closer to the level where the primary process of an organization takes place, but it is also "a

mechanism for concealing, tolerating and stimulating useful incoherence" (ibid). One can understand that other subunits of hospitals will not experience similar ambiguity in their objectives as do ICUs. One can even argue that part of the ambiguity problem of the ICU actually emerges elsewhere but is, together with the patients, transferred to the ICU. Hospitals will therefore allow ICUs a certain level of autonomy in dealing with decisions concerning the admission and discharge of patients. Thus, the nature of the decisions taken within the ICU will not be dependent on the attributes of the hospital in question. These decisions are, instead, dependent upon a variety of other factors in the socio-cultural environment around the ICU (and the hospital). Because the decisions concern matters of life and death, account should be taken of the direct influence of central social values. Some cultures allow explicit discussions about when to refrain from prolonging medical intervention in cases of critically ill patients, while others discourage, or even forbid such discussions. Similarly, the effects of the attributes of the respective health care systems will influence decision making within the ICU. Considering the cost of ICUs (medical and nursing staff, as well as the advanced medical technologies involved) for hospitals, the nature of reimbursement rates for example will influence decision making (are these higher or lower than actual ICU costs?). Moreover, other effects, such as the potential legal consequences of discontinuation of medical intervention, equally influence ICU decision making.<sup>3</sup>

The relative autonomy of the units enables ICUs to develop their own 'routines' with respect to decisions to be made about patients (with respect to admission, discharge and intervention -the latter actually involving the decision to implement particular technologies). It is through these routines that ICUs develop their own specific solutions to the ambiguity problem.

In March's theory, ambiguity in objectives can also be solved by loosely coupling the formulation of the decision and its actual implementation. In the case of decision making within ICUs, this implies that such units will not apply generally applicable rules as to whom to admit to -- or to discharge from the ICU; or how to intervene (and when). Rather, these decisions are negotiated within the ICU. This results in the development and implementation of conventions on how to proceed in particular cases that is more often determined by the past experiences of ICU staff than standard procedures. Although protocols are available in most ICUs, their actual use will be mitigated by local conventions.

While the decentralization of decision making and the delegation of authority will result in differences between the characteristics of ICUs and the hospitals in which they are located, this mechanism of loosely coupling (of formulation and implementation) will result in differences among ICUs.

Consequently, it is expected that ICUs will be characterized by unique sets of routines concerning the central decisions to be made within the unit. For example, instead of making a decision on the severity of illness of each new patient (following some general rule), some ICUs will predominantly choose for less severely ill patients; and others for more severely ill patients. If patients fall outside the routine then the ICU will decide to refer the patient to another ICU.

In fact, this formulation differs only slightly from that used to circumscribe the practice in European professional associations of dividing ICUs in terms of 'levels of care'.<sup>4</sup>

More in particular, it is here presumed that the decision for admission enables a distinction of ICUs on a continuum ranging from ICUs with predominantly less severely ill patients to ICUs with predominantly more severely ill patients.

Similarly, concerning the decision to remove patients, it is presumed that, in this case, a distinction can be made on a continuum ranging from ICUs where patients stay, on average, for a short period of time, to ICUs where patients stay, on average, for a long period of time.

Severity of illness and length of stay within the ICU are, of course, related: patients who are more severely ill will, on average, stay in the ICU longer. However, the claim here is that ICUs have developed routines in both respects. This means that an ICU having developed the routine to hold patients for a longer period of time, will also hold patients for a longer period of time when the patient is less severely ill.

In other words, controlling for diagnosis category and related severity of illness, differences between ICUs should still be found on the two dimensions indicated.

More in particular, given the theory of 'ambiguity solution' as formulated here, it was expected that four types of ICUs would be found (controlling for diagnosis category and related severity of illness). It was anticipated that these four types would be characterized by the following routines concerning admission and discharge:

- i) Type\_1 ICUs: less severely ill patients, staying for a short period of time
- ii) Type\_2 ICUs: less severely ill patients, staying for a long period of time
- iii) Type\_3 ICUs: more severely ill patients, staying for a short period of time
- iv) Type\_4 ICUs: more severely ill patients, staying for a long period of time.

Accordingly, the following hypothesis can be stated:

**Hypothesis I:** ICUs solve the ambiguity problem by developing decision-making routines regarding admission and discharge. Four different types of ICUs can be discerned: characterized by relatively more patients with low or high severity of illness, staying for a shorter or longer period of time within the ICU.

If March's assumption about the loose coupling of these ICUs within the respective hospitals is correct, these four types should not be related to characteristics of the hospitals in which the units are located. Rather, they will be related to other social structural and cultural factors. The latter aspect can only tentatively be addressed in this paper as the nature of the sample (only a small number of cases in each European country) precludes a statistical analysis of the differences between countries.

The first hypothesis can also be read as follows: ICUs cannot be considered one type of organizational unit; given the way they solve the ambiguity problem, they must be seen as different types of organizational units (with different interpretations of their objectives). This would also mean that the contingencies faced by the various types of ICUs should be different.

Comstock and Scott have conceptualized such contingencies in the case of surgical units in hospitals as task and workflow predictability (Comstock and Scott, 1977; Flood and Scott, 1987). Task predictability refers to the degree to which the tasks can be understood (contingencies encountered at the individual level). Workflow predictability refers to the degree to which the workflow can be understood (a contingency at the collective, unit, level).

Applying these concepts to the case of ICUs, it can easily be comprehended that task predictability will be (negatively) related to the severity of illness of patients. If patients are more severely ill, tasks will be more unpredictable: the state of health of such patients can suddenly deteriorate when, for example, patients experience a Multiple Organ System Failure. Similarly, task unpredictability will be (negatively) related to the length of time patients stay in the ICU. Patients staying in the ICU for a long period of time have a greater chance of sudden changes in the state of their health.

ICU staff have two different ways of dealing with these task unpredictabilities: (i) the use of the various types of advanced medical technologies available within the ICU; and, (ii) the specific organizational measures related to task predictability. According to Scott and Comstock these are i) adapting the qualifications of staff; ii) the degree of task differentiation; and, iii) the degree of standardization.

In the following the characteristics of workflow predictability will be addressed prior to considering the organizational measures.

The following hypothesis is posited concerning the relationship between task predictability and technology use:

**Hypothesis II:** Task predictability in ICUs is differentially related to the use of various technologies available within the ICU. Task predictability and technology use vary when comparing the four types.

Some technologies will more directly influence task predictability than others. Moreover, some technologies will only be used in cases of severely ill patients -- some of which will affect task predictability.

It can be expected that, when comparing the four different types of ICUs distinguished above, the relationship between task predictability and technology use will differ.

Workflow predictability refers to the degree the workflow of the ICU can be understood. In the case of ICUs this concerns the degree to which the flow of patients is planned (the more the admission of patients is planned, the higher the workflow predictability). In fact, only some surgical patients are scheduled for admission to the ICU. Other types of patients are unscheduled (for example, unscheduled surgical patients and those with a medical diagnosis). Hence, an adequate operationalization of this dimension of workflow predictability is the proportion of patients within the ICU who were scheduled for admission.

In contrast to the task predictability, the workflow predictability of an ICU is primarily determined by factors outside the ICU. The degree of planning of incoming patients is related to the embeddedness of the ICU in the hospital; referral relationships with other ICUs and hospitals; and referral patterns of patients from the operating room, the recovery room, the emergency room and wards.

One may hypothesize that these referral patterns will be different when comparing the various types of ICUs (e.g., patients originating from the operating theatre will in general stay for a shorter period of time in the ICU, as compared to, for example, patients from the emergency room).

**Hypothesis III:** Workflow predictability in ICUs is related to the embeddedness of the ICU in the surrounding social network of referring organizations and organizational units. Workflow predictability and embeddedness vary when comparing the four types.

The application of the two concepts to the specific situation of the ICU also results in a modification of one of Scott and Comstock's assumptions: that while it is relevant to distinguish task and workflow predictability (because of the different organizational aspects related to both concepts),



they still tend to vary in the same direction (more task predictability will be accompanied by more workflow predictability). If hypotheses II and III can be supported, at least in the case of the four types of ICUs, it is not self-evident that task and workflow predictability will vary in the same direction. In contrast, one may assume that ICUs can simultaneously have a high workflow predictability (a large proportion of planned patients) and yet a low task predictability (especially in ICUs with a high proportion of severely ill patients).

The relationships between task predictability and technology use and between workflow predictability and attributes of the social network around the ICU, indicate two different sources of variation of the contingencies facing the different types of ICUs.

Consequently, it is hypothesized that the relationship between task and workflow predictability varies over the four types of ICUs.

**Hypothesis IV:** The types of ICUs will differ with respect to the relationship between task and workflow predictability.

The two different sources of variation of task and workflow predictability pose the specific organizational problem facing the ICU (i.e., the use of various technologies and the relationship with various organizational actors in the social network around the ICU).

How does an organizational unit deal with two conflicting contingencies (for example, low task predictability and high workflow predictability)?

The specific contingencies of ICUs, which are more pronounced in some of the types (those with more severely ill patients), involve the inconsistency between the levels of task and workflow predictability.

Scott and Comstock distinguished predictability at the individual and collective level because the effect on standardization occurs via different mechanisms. At the individual level, task predictability facilitates standardization by lowering qualifications and increasing task differentiation. At the collective level, workflow predictability influences the degree of standardization by centralizing decision making.

Although working by means of different intermediary variables, task and workflow predictability apparently facilitate the same standardizing effect in organizational structure.

One may expect a similar covariation of task and workflow predictability in the case of ICUs: less workflow predictability because more patients are unexpectedly admitted will be correlated with less task predictability (i.e., patients originate from emergency rooms, other ICUs, other hospitals and wards, instead of being admitted based on a scheduled plan -- originating from the operating

theatre). According to the Scott and Comstock model, the consequence of a relatively low task and workflow predictability in ICUs will be that the qualifications of staff will be high, task differentiation relatively low, and decision-making will be democratic rather than centralized.

However, differences may be expected between the different types of ICUs in the relationship between task and workflow predictability; resulting in interaction effects with respect to the organizational structure. In line with the former two hypotheses it is expected that different organizational structures will emerge in the different types of ICUs. If task and workflow predictability are higher in type\_1 and type\_2 ICUs, compared to type\_3 and type\_4 ICUs, this should be reflected in different organizational structures for the four types.

**Hypothesis V** Type\_1 and Type\_2 ICUs are characterized by relatively lower qualifications, more task differentiation and more centralization; and consequently, more standardization than Type\_3 and Type\_4 ICUs.

To summarize the theoretical argument: Technology application in ICUs reinforces ambiguity with respect to the objectives of these organizational units. This ambiguity is differentially solved by developing decision making routines concerning the admission and discharge of patients. Categories of ICUs defined by these routines face different contingencies; indicated by different technology use and different levels of task and workflow predictability. These different contingencies are related to different organizational reactions.

In the following, the above hypotheses are tested using material on the 80 European ICUs.

### **3. Methods and data**

The data were collected in the period October 1994 - January 1995 from 16059 patients in 89 European Intensive Care Units. Data collection was anonymous. The data were double-checked (at the country level and at the level of the central data processing centre -- the University Hospital in Gronngen).<sup>5</sup>

The objective of the study, EURICUS-1 (financed under the aegis of the EU BIOMED-1 program), was to analyze the non-medical determinants of medical performance of ICUs. Stratified regional samples were drawn in 12 countries in order to yield a large range of different Intensive Care Units. Consequently, no representativity for the population of European ICUs can be claimed.

The participating countries were Poland, Germany, Denmark, Finland, Netherlands, Belgium, France, United Kingdom, Italy, Spain, Spain-Catalonia, Portugal. Two regional areas in Spain participated in the study (Catalonia and Valencia). An additional nine Spanish ICUs participated in the study, but have been excluded from the analysis reported in this study. As a result, the present analysis concerns 14835 patients in 80 European ICUs.

The sampled ICUs are part of public (81.6%) or private (18.4%) hospitals; comprising university (38.2%) and non-university (61.8%) hospitals. The size of the ICUs in the sample ranges from 4 to 33 beds.

While the study used different methods of data collection, the data in the present study have been derived from the scoring systems administered daily by doctors and nurses in the ICU: the SAPS-II and NEMS, and (with respect to the organizational variables) from a questionnaire answered by the directors of the participating ICUs.

#### **Diagnosis Categories**

For each patient the nature of the diagnosis is indicated. The 19 diagnosis categories distinguished by Knaus et.al. were used in the study. These categories were used as a control variable: severity of illness and the measures of technology use were calculated for each of the diagnosis categories.

## Measuring the objectives

Two measures were used to indicate the different interpretations of the objectives of ICUs: *severity of illness* and *length of stay*.

Severity of illness was measured by the SAPS-II scoring system; SAPS-II scores severity of illness of patients after 24 hours in the ICU.<sup>6</sup>

The length of stay measure (LOS) indicates the number of days a patient stays in the ICU. A LOS of 0 indicates a stay shorter than one full day.

In order to use the SAPS II and LOS scores for the distinction of the types of ICUs, the effect of different diagnosis categories on both measures were controlled for by using the deviations from the mean for each of the diagnosis categories.

The data on technology use and task and workflow predictability were derived from the NEMS scoring system as administered by nurses (NEMS stands for **N**ine **E**quivalents of **N**ursing **M**anpower use **S**core). This scoring system measures the daily nursing workload at patient level. For the initial 16059 patients, 76976 NEMS observations were made.

Because the NEMS also comprise an indication of the nature and number of technologies used in the ICU, this measure could be used as the basis for both the indicators of technology use (our independent variables) and the predictability of tasks and workflow (our dependent variable).

Daily NEMS scores are available for each patient.

In order to use the NEMS scores for the construction of the dependent variables, the technologies scores were removed from the total NEMS scores of patients. The resulting NEMS scores indicate the 'size' of the daily tasks of the nurses for a patient during his/her stay in the ICU.

## Task Predictability

The difference between the maximum and minimum NEMS score (without technologies) is considered an indicator of the task unpredictability. The larger the difference, the more difficult it was to predict the task of the nurses at the time of arrival of the patient. In order to control for the medical effects on task predictability, it was necessary to control for the effects of severity of illness and diagnosis category.

In the analysis, the negative logarithm of the difference (controlling for severity of illness and diagnosis category) was used to indicate the task predictability of patients (in order to normalize

the distribution of the variable). Task predictability of an ICU was indicated by the negative of the mean of the logarithm of the difference at the individual level.

## Workflow Predictability

Workflow predictability (the degree of planning of the flow of incoming patients) was operationalized by a dichotomous variable indicating whether a patient was scheduled. Accordingly, at the ICU level, workflow predictability was operationalized as the proportion of patients in the ICU who were scheduled.

## Technology Use

During the stay of each patient in the ICU, the use of the following regular intensive care technologies is measured by the NEMS score: a) basic monitoring; b) intravenous medication; c) mechanical ventilatory support; d) supplementary ventilatory care; e) single vaso-active medication; f) multiple vaso-active medication; g) dialysis techniques. It is indicated whether the patient had h) specific interventions in the ICU and/or i) specific interventions outside the ICU.

The measures of 'technology use' were calculated by dividing the number of times the various technologies were used by the number of days the patient stayed in the hospital. By calculating the deviations of the measures from the mean for each of the diagnosis categories, it was possible to control for the latter variable. By dividing the eventual scores by the respective SAPS-II score for each patient, the technology-use measures were standardized for severity of illness.

At the ICU level, mean scores of each of the technology-use measures were calculated.

The organizational variables were operationalized by a questionnaire answered by ICU directors. The respective variables were operationalized as follows.

*Task differentiation:* The ICU director was asked to indicate to what extent the tasks of the various medical and nursing professionals in the ICU were taken over by other professionals. Factor analysis of the items revealed three different dimensions: I (explaining most of the variation) the exchange of tasks between medical and nursing staff **downward** in the hierarchy of the ICU (headnurses taking over the tasks of physicians and nurses taking over the tasks of head nurses); II the opposite **upward** dimension; and III, the exchange of tasks between the

medical staff (physicians-residents).

In the case of the medical-nursing tasks exchanges, the differences are confined to those falling within the categories "rarely" and "never". In the case of the exchange of tasks within the categories of nurses, the range is larger, and there is no difference between upward and downward exchange of tasks.

Three different scales were constructed, measuring task exchange medical-->nursing (downwards) ; task exchange medical <---nursing (upwards) and the exchange of tasks within the category of nurses. No separate scale was formed for the exchange of tasks within the medical category (because of the large number of missing values).

*Qualifications:* Differences between ICUs in terms of the qualifications of the staff were measured by establishing the percentage of nursing staff with special CC-training, present in the ICU. Because of the large differences between European countries in terms of the existence of formal CC training for medical personnel (only in Spain were intensivists considered a separate specialty), the qualifications of the medical staff were not included in this measure.

*Centralization:* Centralization of decision making was measured by asking ICU directors about decisions regarding the admission and discharge of patients. This variable was trichotomized to indicate the difference between three different states: an ICU director deciding alone about admission and discharge; an ICU director deciding alone about either admission or discharge, the other decision being made together with others; and the ICU director making decisions on admission and discharge together with others.

*Standardization:* Standardization was measured by asking the ICU director to indicate the frequency of use of protocols.

## 4. Analysis

The first hypothesis claims that ICUs develop unique routines regarding admission and discharge decisions. Consequently, ICUs are expected to be characterized by unique configurations of patients with ICU specific combinations of severity of illness (related to the admission decision) and length of stay (related to the discharge decision).

Instead of finding comparable ICUs with random combinations of patients with differing characteristics regarding severity of illness and length of stay (presuming that only patient characteristics do matter for physician decision), it was expected that different **types** of ICUs would be found, each characterized by a specific dominance of the combination of severity of illness and length of stay.

As indicated above, decisions regarding the admission of patients were operationalized by considering the mean severity of illness of patients in the ICU (measured with the SAPS-II scale), controlling for the diagnosis categories.

Decisions regarding discharge of patients were operationalized by the mean length of stay in the ICU; also controlling for the diagnosis categories.

Taking from each of these variables the 25th percentile (indicating a mean low score on the two variables), and the 75th percentile (indicating a mean high score on the two variables), made it possible to distinguish four categories of ICUs.

These categories comprise patients with, respectively, a) a relatively low mean severity of illness (25th SAPSII) and short stay (25th LOS); b) low mean severity of illness (25th SAPSII) and long stay (75th LOS); c) high mean severity of illness (75th SAPSII) and short stay (25th LOS); and, d) ICUs with a high mean severity of illness (75th SAPSII) and long stay (75th LOS).

The respective frequencies of the four categories are indicated in Table 1.

### **Table 1 about here**

Table 1 indicates that 45 of the 80 ICUs can be classified by the combined SAPSII/LOS variable. To test the hypothesis that these categories encompass ICUs with unique combinations of patients, the 'within and between' variations of the SAPSII and LOS variables were considered (Table 2).

### **Table 2 about here**

Table 2 supports the view that the categories of ICUs can be considered different types of ICUs, characterized by different routines for decisions on admission and discharge. In all cases the 'between' variation is significant.

According to March's notion of 'loose coupling' it is to be expected that the distinguished ICU types are not related to the characteristics of the hospitals in which they are located.

Table 3 indicates the chi square distributions of the crosstables between the 'types' distribution and the frequency of patient referrals from other ICUs and other hospitals; the type (university or non-university); status (private/public) and size of the hospital.

### **Table 3 about here**

All relationships are non-significant: only in the case of the relationship between the central variable and the types of hospitals one can find a tendency (though not significant) that university hospitals have different types of ICUs than non-university hospitals.

This relationship is rather self-evident; university hospitals have ICUs with relatively more severely ill patients.

In the last row of table 3 the relationship of the types of ICUs and the distribution over countries is indicated. As revealed by the significance of the chisquare, the various types of ICUs are closely related to the distribution of European countries. More in particular, different types of ICUs predominate in different countries. The first type (ICUS with patients who have, on the average, a lower severity of illness, and stay for a shorter period of time) is primarily found in Northern continental Europe. The third type (high severity of illness and shorter stay) is found in the UK. The fourth type (high severity of illness and long stay) is found in the Southern part of Europe (especially in Italy and Portugal).

It can be expected that this uneven distribution of the types of ICUs over Europe is related to such factors as the nature of the health care system (when reimbursement rates of ICUs are lower than actual costs, one will find shorter stays) and culture (some cultures are more reluctant to accept withdrawal of treatment in cases of untreatable terminal illnesses than others). However, it was not possible to test the effects of such factors because the number of ICUs per country was too small to facilitate a multivariate analysis.

It is the central contention of this paper that the relationship between technology use and



organizational structure is contingent upon these different types, being the consequences of the various routines chosen.

More specifically, the second hypothesis states that technology use (differentially) affects task predictability with the different types as the intervening factor.

In Table 4 the multiple regression of task predictability on the various technologies as used within ICUs is indicated. Three of the types of ICUs have been included as dummy variables (the fourth, low severity of illness/long stay, has too low a frequency to facilitate a more definitive analysis).

#### **Table 4 about here**

The first column in Table 4 gives the results of a model using all 80 ICUs; the other columns give the results using, respectively, type\_1; type\_3 and type\_4 ICUs as dummy variables. Table 4 shows that the general model does not fit well: the fit of the models is considerably improved using the types of ICUs as dummy variables.

According to the first model, only the use of ventilation support significantly affects task predictability in a negative way ( $\beta = -.310626$ ).

Comparing the models as represented in the last three columns, interesting differences can be observed between the three types.

First, the separate effects of the three types on task predictability are different: types\_1 and \_3 have a significant positive effect on task predictability; type\_4, however, has a significant negative effect. The explanation for the negative effect in the case of ICUs with more severely ill patients who stay longer could be that a longer stay will result in less task predictability. This is because during a longer stay the chances that unexpected deteriorations of the state of health of already severely ill patients increase.

Some of the technologies have similar effects on task predictability in all three types of ICUs: the frequency of special interventions within the ICU, and administering single vaso-active drugs have, in all cases, a significant negative effect on task predictability. However, the utilization of ventilation support only significantly reduces task predictability in ICUs with severely ill patients.

Finally, in some cases, the utilization of more basic technologies (which are generally applied in ICUs) such as the administering of intravenous medication and basic monitoring, have contrasting effects. One would expect that the application of such basic technologies would not -- or only positively, affect task predictability. This appears to be the case. These technologies are not significantly related to task predictability; although in the case of administering intravenous

medication, task predictability is positively affected by the utilization of this technology in ICUs with less severely ill patients who stay for a shorter period of time (type\_1).

Summarizing, Table 4 reveals that within the three different types of ICUs (the fourth type was excluded from the analysis) task predictability is differentially affected by the utilization of the various IC technologies.

The third hypothesis claims that workflow predictability, in contrast to task predictability, is not affected by technology use, but by the inter-organizational relationships around the ICU.<sup>7</sup>

#### **Table 5 about here**

Table 5 indicates the multiple regression of workflow predictability (operationalized as the percentage of patients that are scheduled) on the interorganizational variables. In those cases in which the preliminary analysis indicated that the variables were not normally distributed, the variables have been transformed to the logarithm. The variable indicating the proportion of patients originating from the operating theatre was not included. The reason for this was the relationship with the proposed dependent variable (all scheduled patients originate from the operating theatre). Also in this case models involving all 80 ICUs have been included, together with a comparable model including the categories of the 'types'- variable as dummy variables (excluding the second type, considering the restricted number of data).

As can be seen in table 5, the model for the total sample (column 1), including all remaining inter-organizational variables, fits rather well. In descending order, workflow predictability is decreased by the proportion of patients coming from other hospitals (beta= -.46976), from the emergency room (beta=-.419177), from wards (beta=-.254885), and from other ICUs (beta=-.248225).

Including the dummy variables for the three types in the model considerably decreases the fit of the model. Furthermore, in the model with the type\_1 dummy variable (low severity of illness/short stay), only the proportion of patients from other hospitals and wards significantly affect workflow predictability (column 2). In the remaining two models (columns 3 and 4) only the proportion of patients from wards has a significant negative effect on workflow predictability (the effect of the proportion of patients coming from other hospitals is still substantial, but not significant).

Including the dummy variables for the types particularly reduces the effects of the variables 'patients from other ICUs' and 'patients from the emergency room'.

Table 5 also reveals that, in contrast to the models predicting the variation of task predictability, the differences between the types of ICUs in terms of the prediction of workflow predictability do not occur. In this respect, hypothesis III cannot be supported.

It is feasible that a relationship between workflow predictability and the typology of ICUs is masked by the effect of the country variable. I will return to the effect of the country variable below.

Thus far, it appears that it is not self evident that task and workflow predictability in ICUs vary in congruence. Hypothesis IV states that this relationship is contingent upon the typology of ICUs.

Table 6 provides the correlations between task and workflow predictability for the total sample of ICUs and the four different types.

#### **Table 6 about here**

Table 6 reveals that there are substantial differences between the types of ICUs in terms of the relationship between task and workflow predictability. Leaving out of consideration the relationship in the case of type\_2 ICUs (because of the small number of cases), the table shows an especially large difference between ICUs with i) predominantly severely ill patients staying for a long period of time (type\_4 ICUs), and ii) and the other types of ICUs. In the case of type\_4 ICUs, the relatively small positive correlation between task and workflow predictability disappears.

As indicated above, the different types of ICUs are unevenly distributed over Europe. It is possible that the different types of ICUs (or different configurations of patients) co-vary in different parts of Europe with different combinations of task and workflow predictability.

To investigate this relationship, the ICUs were dichotomized according to a geographical distribution: Northern ICUs (except those in Italy, Spain and Portugal and the specific case of Poland), and Southern ICUs (those in Italy, Spain, and Portugal).

Surprisingly, it appears that the relationship between task and workflow predictability is in strong contrast in these two regions of Europe. In the Northern ICUs, there is a positive correlation between task and workflow predictability ( $r = +.30$ ); while in the Southern ICUs, the correlation is negative ( $r = -.30$ ).

Apparently, the country variable interferes with the typology variable. Unfortunately, due to the small number of ICUs in the sample and the relationship between the typology and the country

variable, it was not possible to compare the types of ICUs c Aontrolling for the country variable (Type\_1 and Type\_3 ICUs are predominantly found in the Northern part of Europe; while Type\_4 ICUs are for the most part to be found in the Southern part of Europe).

To assess the evidence for the last hypothesis (stating the relationship between the types of ICUs and different organizational structures), it would have been necessary to separate the effect of the typology and the country variable. Instead, using the mean values for the organizational variables, 'organizational profiles' of the types are given (Type\_2 is excluded because of the low frequency of this type) (see Table 7).

#### **Table 7 about here**

The ICUs with predominantly relatively less severely ill patients, who stay for a shorter period of time (Type\_1 ICUs in Northern and continental Europe) are characterized by relatively less centralized decision-making (notwithstanding a relatively high workflow predictability).

ICUs with relatively more severely ill patients, who stay for a longer period of time (Type\_4 ICUs in Southern Europe) are characterized by centralized decision making (without any variation) -- although the workflow predictability is relatively low. The ICUs with relatively more severely ill patients who stay for a shorter period of time (Type\_3 ICUs in Northern Europe -- predominantly the UK), have intermediate levels of workflow predictability and a degree of centralization of decision making.

As to the relationship of task predictability, on the one hand, and the qualifications of staff and task differentiation on the other, similar deviations from the hypothesized relationships in the model can be found (as formulated by Scott and Comstock). Task predictability is highest in Type\_2 ICUs; but this is not related to a relatively low level of qualifications and high degree of task differentiation.

Table 7 shows that Type\_1 ICUs are characterized by relatively high levels of qualifications of the nursing staff. Type\_4 ICUs do not, for the most part, have nursing staff with special CC training. Also in this respect the Type\_3 ICUs take an intermediate position. The difference in qualifications between the three types of ICUs is clearly related to different experiences in different parts of Europe with the training of CC-nurses (rather than differences in terms of task predictability). This also applies with respect to the differentiation of tasks.

Type\_4 ICUs in Southern Europe have relatively high levels of task differentiation between medical and nursing staff upwards (but a relatively low level downwards), as well as task differentiation between the nursing staff.

In the cases of Type\_1 and Type\_3 ICUs, the three different ways of measuring task differentiation do not differ very much (Type\_1 having a slightly higher level overall of task differentiation, compared to Type\_2).

Finally, all types of ICUs are generally characterized by low levels of standardization.

Summarizing, the main differences in organizational characteristics between the three types of ICUs are to be found between the ICUs in Northern and Southern Europe, rather than being related to the differences of task and workflow predictability.

Although the small number of cases preclude a statistical analysis of the differences, the figures in Table 7 point to the predominant effects of the surrounding culture and/or health care system on organizational characteristics of European ICUs.

Although it was possible to find differences between the types of ICUs in terms of technology use, these differences seem to disappear when the country variable is taken into account.

## **5. Discussion and conclusions**

The evidence in this paper suggests that technology application within an organizational unit such as an ICU does not directly influence the organizational structure. Such effects are dependent on the interaction between the technology application and decision making about objectives within the organization.

When comparing the different types of organizational units that can be identified on the basis of the interpretations of the central decisions taken (in our case the decisions to admit and discharge patients), it can be seen that the contingencies faced by these organizational units are different.

Congruent with the findings of Scott and Comstock, technology seems to have different effects at the individual and collective level. The present study clearly indicates the distinct effects of task and workflow predictability, and accounts for the different sources of task and workflow predictability. In this case, task predictability seems to be more related to the nature of the tasks at hand, and hence to the effects of specific technologies. Workflow predictability, on the other hand, is related to the inter-organizational structure around the ICU.

This points to a new way of conceptualizing the relationship between the internal and external aspects of organizations.

Organizational structures of ICUs are shown to be differentially dependent upon the application of different technologies, mediated by the definition of their objectives. As these objectives are

also defined by cultural elements, the comparison of ICUs over Europe shows a double influence:

- the effects of the differential definition of goals related to the tasks within an ICU;
- cultural elements resulting in the preponderance of specific forms of *task differentiation* (in some European cultures the sharing of tasks between differentially hierarchically placed actors is more easy than in others), and *centralization* (in some European cultures hierarchy is more persistent, even in work environments in which team work seems to be necessary -- given the tasks at hand).

Unfortunately, the size of the country samples precluded adequately separating the technological/internal sources of the differences of organizational structure and the cultural sources.

Nevertheless, these results do show the usefulness of quantitative, comparative organizational analyses, even for European organizational sociology.

**Table 1. Types of ICUs; frequency of patients and ICUs**

	N patients		N ICUs	
type 1 short-low	2650		14	
type 2 long-low	789		5	
type 3 short-high	1119		10	
type 4 long-high	1288		16	
rest ICUs (50/50 LOS/SAPSII)	8989		35	
<b>Total</b>	<b>14835</b>		<b>80</b>	

**Table 2. Differences between the four categories of ICUs in terms of Length of Stay (LOS) and Severity of Illness (SAPS\_II) at patient level.**

**LOS**

<b>Group</b>	<b>Count</b>	<b>Standard</b>		<b>Error</b>	<b>95 Pct</b>	<b>Conf</b>	<b>Int for Mean</b>
		<b>Mean</b>	<b>Deviation</b>				
Type_1	2649	3.7634	7.5941	.1475	3.4741	To	4.0528
Type_2	789	6.6327	8.4269	.3000	6.0438	To	7.2217
Type_3	1117	4.6067	8.3118	.2487	4.1187	To	5.0947
Type_4	1288	9.4798	16.6439	.4638	8.5700	To	10.3896
<b>Total</b>	<b>5843</b>	<b>5.5722</b>	<b>10.7296</b>	<b>.1404</b>	<b>5.2970</b>	<b>To</b>	<b>5.8473</b>

**SAPS-II**

<b>Group</b>	<b>Count</b>	<b>Standard</b>		<b>Error</b>	<b>95 Pct</b>	<b>Conf</b>	<b>Int for Mean</b>
		<b>Mean</b>	<b>Deviation</b>				
Type_1	2623	28.2695	18.1384	.3542	27.5751	To	28.9640
Type_2	787	31.3609	17.5387	.6252	30.1336	To	32.5881
Type_3	1107	38.1382	19.4506	.5846	36.9912	To	39.2853
Type_4	1283	40.7545	19.0047	.5306	39.7136	To	41.7954
<b>Total</b>	<b>5800</b>	<b>33.3343</b>	<b>19.2658</b>	<b>.2530</b>	<b>32.8384</b>	<b>To</b>	<b>33.8302</b>



**Table 3, Relationships interorganizational attributes with the types of ICUs (Chisq)**

	Chisq	DF	Sign.
other ICUs	2.38647	3	.49616
other hospitals	2.94882	3	.39958
type of hospital (univ/non-univ)	6.49286	3	.08994
status of hospital (private/public)	3.97321	3	.26437
size hospital	1.86719	6	.93150
country	61.24821	30	.00065

**Table 4. Multiple regression of task predictability on use of various technologies**  
(controlled for diagnosis categories and severity of illness) and types of ICUs.

	Beta	T	Beta	T	Beta	T	Beta	T
SPEC_WITHIN	-.082313	-.690	-.271625	-1.701	-.322385	-2.205	-.284797	-1.856
SPEC_OUTSIDE	-.099601	-.823	.123592	.786	-.117016	-.764	-.090476	-.553
SUPPL_VENT	-.112183	-.703	-.113164	-.475	-.130176	-.609	-.119834	-.530
MVASO_ACT	.132567	1.092	-.060563	-.371	.030933	.204	-.049199	.301
SVASO_ACT	-.192878	-1.664	-.559289	-3.486	-.386072	-2.708	-.418480	-2.803
VENT_SUP	-.310626	-2.444	-.158884	-1.028	-.254024	-1.776	-.280705	-1.812
DIALYSIS	.018984	.113	.086794	.366	.161133	.74 5	.060087	.263
INTRAV_MEDIC	.287819	1.328	.510019	1.829	.284330	1.125	.448256	1.703
BASIC_MONIT	-.283365	-1.033	-.651835	-1.726	-.113460	-.328	-.531163	-1.526
TYPE_1 (S-L)			.311902	1.720				
TYPE_3 (S-H)					.422492	3.236		
TYPE_4 (L-H)							-.394333	-2.451
CONSTANT		7.965		7.596		7.777		7.880
Adj. R Sq.= .078    Adj.R Sq.=.371    Adj.R Sq.=.477    Adj.R Sq.=.419								
F = 1.74363    F = 3.59614    F = 5.01913    F = 4.173161								
Sign. F = .0952    Sign. F = .0024    Sign. F = .0002    Sign. F = .0008								

**Table 5 Multiple regression of workflow predictability on various interorganizational variables and types of ICUs.**

	Beta	T	Beta	T	Beta	T	Beta	T
ADM_OTH_HOSP(ln)	-.469726	-4.388	-.555224	-1.968	-.437731	-1.496	-.435861	-1.537
ADM_OTH_ICU(ln)	-.248225	-2.457	-.033704	.134	-.106735	-.452	-.171599	-.592
ADM_EMERGENCY	-.419177	-3.948	-.186787	-.758	-.125351	-.446	-.160213	-.612
ADM_RECOV(ln)	-.123047	-1.206	.012173	.041	.150873	.495	.130829	.453
ADM_WARD	-.254885	-2.416	-.494103	-2.160	-.516920	-2.038	-.493563	-2.021
TYPE_1 (S-L)			.275644	1.131				
TYPE_3 (S-H)					-.036102	.153		
TYPE_4 (L-H)							.107242	.396
CONSTANT		-.454		.598		.819		.589
Adj. R Sq. = .734    Adj. R Sq. = .405    Adj. R Sq. = .322    Adj. R Sq. = .332								
F = 18.08982        F = 2.70331        F = 2.18982        F = 2.24432								
Sign. F = .0000      Sign. F = .0873      Sign F = .1398      Sign. F = .1327								

**Table 6. Correlations between task and workflow predictability for the four types of ICUs and for the total sample.**

Correlations between task and workflow predictability (Pearson's R)	
total sample	R = .10
Type_1 (S-L)	R = .43
Type_2 (L-L)	R = -.65
Type_3 (S-H)	R = .34
Type_4 (L-H)	R = -.04

**Table 7. Mean values of the organizational variables and task and workflow predictability**

**for type\_1 ICUs (north); Type\_3 ICUs (north) and type\_4 ICUs (south).**

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	<b>type_1 (north)</b>	<b>type_3 (north)</b>	<b>type_4 (south)</b>
<b>mean:</b>			
adm_disc_dec	3.0833	3.1250	4.000
qualif	63.3833	40.7375	.8383
taskdiff_down	3.1667	2.7143	2.6667
taskdiff_up	3.1429	3.0000	3.8333
taskdiff_nurs	3.0833	2.8571	3.3333
standardization	1.6667	1.6250	1.6667
workflow predict	.2565	.1930	.1545
task predict	1.2322	1.4381	1.2954

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## Notes

1. This does not significantly deviate from Bates and Thompson's initial view that modern technologies are so complex that they need modern complex organizations.
2. March has also (see Levinthal/March, 1988) dealt with technological changes in this way.
3. The chances for a patient in an American hospital to be admitted to the ICU are about ten times higher than for patients in European hospitals. This difference can only be accounted for by the different attitude in American hospitals regarding the administering of the most advanced medical technologies (in order to preclude potential legal consequences).
4. See the convention accepted in the European Society of Intensive Care Medicine to indicate three levels of care, each characterized by a specific level of severity of illness of patients and intensity of (nursing) care. The use of so-called 'scoring systems' (such as the APACHE system in the US, and the SAPS system in Europe) does not preclude such local decision making; it only facilitates the quantification of the characteristics of the incoming patients.
5. The research project EURICUS-1 was coordinated by Dr. D. Reis Miranda (University Hospital, University of Groningen). I want to express my gratitude to Drs. Jaro van der Veen for his help in preparing the medical data for this organizational study.
6. For a detailed account of the SAPS II scoring system, see Le Gall, et.al., 1993.
7. Regression models with workflow predictability as dependent variable and the technology use variables did not fit. Only the dialysis variable had a significant negative effect on workflow predictability. In the case of type\_1 ICUs, the application of special interventions outside the ICU positively affected workflow predictability. This variable, of course, can also be considered as a different operationalization of the interorganizational relationships around ICUs.

## Literature

Barley, Stephen R., 1990, 'The Alignment of Technology and Structure through Roles and Networks', **Administrative Science Quarterly**, 35:61-103

Byrne, Paul, 1997, 'Intensive Care Technology - Friend or Foe?', **Bioethics Bulletin**, 6.4:1-3

Comstock, Donald E., and W. Richard Scott 1977 'Technology and the structure of subunits: Distinguishing individual and workgroup effects', **Administrative Science Quarterly**, 22:177-202

Flood, Ann Barry, and W. Richard Scott, 1987, **Hospital Structure and Performance** , Baltimore: Johns Hopkins University Press

Hickson, David J., D.S. Pugh, and Diana C. Pheysey 1969, 'Operations Technology and Organization Structure: An Empirical Reappraisal', **Administrative Science Quarterly**, 14:378-397

LeGall, Jean\_Roger, Stanley Lemeshow, Fabienne Saulnier, 1993, 'A New Simplified Physiology Score (SAPS II) Based on a European/North American Multicenter Study', **JAMA**, December 22/29, 270, no.24, pp. 2957-2963

Levinthal, D. and J.G. March, 1988, 'A model of adaptive organizational search', in March, James G., **Decisions and Organizations**, Chapter 9, Oxford: Basil Blackwell

Lynch, Beverly P., 1974, 'An empirical assessment of Perrow's technology construct', **Administrative Science Quarterly**, 19:338-356

March, James G., 1994, **A Primer on Decision Making. How Decisions Happen** , New York, etc: The Free Press

March, James G., 1988, **Decisions and Organizations**, Oxford: Basil Blackwell

Mintzberg, Henry, 1979, **The Structure of Organizations** Englewood Cliffs, NJ: Prentice-Hall

Mohr, Lawrence B., 1971 'Organizational technology and organizational structures', **Administrative Science Quarterly**, 16:444-459

Orlikowski, Wanda J., 1992 'The Duality of Technology: Rethinking the Concept of Technology in Organizations', **Organization Science**, 3: 398 - 427

Overton, Peggy, Rodney Schneck, and C.B. Hazlett, 1977, 'An Empirical Study of the Technology of Nursing Subunits', **Administrative Science Quarterly**, 22:203-217

Perrow, Charles 1967 'A framework for the comparative analysis of organizations' **American Sociological Review**, 32:194-208

Perrow, Charles, 1970, **Organizational Analysis: A Sociological View**, Belmont, Ca: Wadsworth

Thompson, James D., and Frederick L. Bates 1957 'Technology, Organization, and Administration', **Administration Science Quarterly**, 2:32-343. Reprinted in **Organization and Beyond**, Selected Essays of James D. Thompson, William A. Rushing/ Mayer N. Zald (eds), Lexington Books, D.C. Heath & Co. Lexington Mass, 1976

Woodward, Joan 1958 **Management and Technology**, London: Her Majesty's Stationery Office

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